How Randomness Affects Our Decisions for Radiation Safety

A 15 Minute Technical Paper
(MPM.7)

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by

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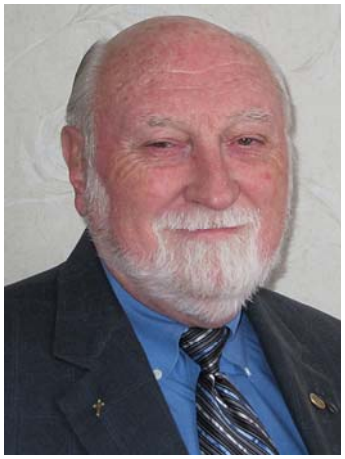
As health physicists we understand that radiation is a random phenomenon and that our practice of ALARA is to minimize the future random chance of cancer. Thus, dealing with randomness is a normal part of our practice as specialists in radiation safety. Unfortunately, most of the rest of the world wants to deal only with absolutes and does not want to know about uncertainty or probabilities. Most people want specific answers to questions such as, “Am I safe or not safe?” “Will I be harmed or not harmed?” Most people do not want to hear about risk estimates. When presented with a probability of cancer as a risk of one out of some number of those exposed, they will often conclude that they are the one. Or, not understanding risk probabilities, they may substitute an easier question, such as, “How do I feel about getting cancer?” This is a question they can readily answer without any knowledge of radiation science or statistics. This approach eliminates any concerns for randomness or probabilities. Everyone knows of someone who has had cancer and they are aware of the awful consequences. The prospects of radiation causing cancer become an overwhelming influence on decisions for radiation safety. Our natural human instincts for safety are not well suited to situations involving randomness or uncertainty. Thus, while people may not be certain about the risks of radiation effects, they are certain that they do not want to become a victim of cancer. Research has shown that, when chance is involved, peoples’ thought processes are often seriously flawed. When information is lacking this invites competing interpretations. Unfortunately, misinterpretation of data may have very negative consequences. This paper will look at how we make choices and the processes that lead us to make poor decisions for radiation safety when confronted with randomness and uncertainty.



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- BS - Civil Engineering, University of Vermont (1961)
- MS - Sanitary Engineering, Massachusetts Institute of Technology (MIT) (1963)
- PSE - Professional Sanitary Engineer Degree, MIT and Harvard University (1963)
- PE – Licensed Professional Engineer, Vermont (1965 – present)
- PhD Studies, Radio and Nuclear Chemistry, Rensselaer Polytechnic Institute (1966–1972)
- Greater Washington Institute for Transactional Analysis - Counseling (1977–1980)
- CHP – Certified Health Physicist, American Board of Health Physics (1983–present)
- Johns Hopkins Fellow, Organizational Systems and Communications (1984–1985)
- FHPS - Fellow of the Health Physics Society and Past President (2000)
- Past President, American Academy of Health Physics (2013)
- Commissioned Stephen Minister – Counselor, United Methodist Church (2003–present)

Experience

2010 – pres.	Director , Radiation Safety Counseling Institute. Workshops, training, and counseling for individuals, companies, universities, or government agencies with concerns or questions about radiation and x-ray safety. Specialist in helping people understand radiation, what is safe, risk communication, worker counseling, psychology of radiation safety, and dealing with fears of radiation and nuclear terrorism for homeland security.
2007 – pres.	VP, Training Programs and consultant to Dade Moeller Radiation Safety Academy, training and consulting in x-ray and radiation safety, safety program audits, radiation instruments, and regulatory requirements.
1984 - 2007	Director, Radiation Safety Academy. Providing x-ray and radiation safety training, audits, and consulting to industry (nuclear gauges and x-ray), universities, research facilities, and professional organizations.
1988 - 2006	Manager and Contractor to National Institutes of Health (NIH) for radiation safety audits of 3,500 research laboratories and 2,500 instrument calibrations a year, along with environmental monitoring, hot lab and analytic lab operations, and inspections of three accelerators and over 100 x-ray machines.
1990 - 2005	President of Key Technology, Inc. a manufacturer and primary laboratory for radon analysis with over 1,500,000 measurements since 1985. Primary instructor at Rutgers University for radon, radon measurements, radiation risks, radiation instruments, and radon risk communication courses (1990-1998).
1986 - 1988	Laboratory Director, RSO, Inc. Directed analytical programs and Quality Assurance for samples from NIH, Aberdeen Proving Ground, radiopharmaceutical companies, and the nuclear industry.
1970 - 1985	Chief, Radiation Surveillance Branch, EPA, Office of Radiation Programs. Directed studies of radiation exposures from all sources of radiation in the US, coordinated 7 Federal agencies for nuclear fallout events, QA officer 8 years. Head of US delegations to I.A.E.A and N.E.A. on radioactive waste disposal. ANSI N-13 delegate (1975-1985). Retired as PHS Commissioned Officer (0-6) in 1985 with 29 years of service.
1963 - 1970	U.S.P.H.S. Directed development of radiation monitoring techniques at DOE National Labs, nuclear plants, and shipyards in the US and Chalk River Nuclear Laboratory in Canada.

Health Physics and Professional Activities

Health Physics Society (HPS) plenary member 1966; President-elect, President, Past President (1998-2001), Fellow (2000), Treasurer (1995-1998); Secretary (1992-1995); Executive Cmte. (1992-2001), Chair, Finance Cmte. (1996-1998); Head of U.S. delegation to IRPA X (2000). RSO Section Founder and Secretary/Treasurer (1997-2000); Co-founder and President, Radon Section (1995-1996). Co-Chair Local Arrangements Cmte. Annual Meeting in DC (1991); Public Info. Cmte. (1985-1988); Summer School Co-Chair (2004); Chair, President's Emeritus, Cmte (2006); Chair, Awards Cmte. (2002); Chair, History Cmte. (2005-2012); Historian (2012-Pres.) Continuing Education Cmte. (2005-2012). Academic Dean for HPS Professional Development School on Radiation Risk Communication (2010). PEP, CEL and AAHP Instructor; Journal Reviewer; Treasurer, AAHP (2008 – 2011). AAHP President-elect, President, Past President (2012-2014). Baltimore-Washington Chapter: President (1990-1991) and Honorary Life Member; Newsletter Editor (1983-2005); Public Info. Chair (1983-1991), Science Teacher Workshop Leader (1995 – Pres.). New England Chapter HPS, Newsletter Editor, Board of Directors, Education Chair (1968-1972). President, American Association of Radon Scientists and Technologists (1995-1998) and Honorary Life Member, Charter Member; Board of Directors; Newsletter Editor (1990-1993). Founder and first President, National Radon Safety Board (NRSB) (1997-1999). Member of American Industrial Hygiene Association (1997-Pres.) (Secretary, Vice Chair, Chair, Ionizing Radiation Committee, 2009-2012), Conference of Radiation Control Program Directors (1997-Pres.), Studied H.P. communication styles and presented Myers-Briggs seminars to over 3500 H.P.s since 1984. Over 35 professional society awards. Licensed Professional Engineer since 1965. Certified Health Physicist since 1983.

Publications

Authored over 500 book chapters, articles, professional papers, training manuals, technical reports, and presentations on radiation safety. Author of monthly column, "Insights in Communication" HPS Newsletter 1984 – 1989, 1994 -2001, and 2012- 2013.

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Have You Been Puzzled By - - ?

- How people can make such fast decisions for safety with little data or understanding
- How they can be so sure of their decisions
- How illogical they may seem
- How emotions affect safety decisions
- How people lack a number sense
- Lack of understanding of magnitudes and probabilities
- Lack of understanding randomness

Randomness and Radiation Safety

- Dealing with randomness is normal for health physicists
- Radiation is a random phenomenon
  - All measurements are samples from a random distribution and are only best estimates
- The practice of ALARA is to minimize future random chance of cancer
  - Stochastic effects
- We use LNT as a model for safety practices

What the World Wants

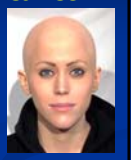
- To deal only with absolutes
- People do not want to know about uncertainty and probabilities
- Most people just want to know, "Am I safe or not safe?"
- They do not want to know about risk estimates
- When presented with a risk of 1 / 10,000
  - Many will conclude they are the 1

How People Handle Probabilities

- Not understanding risk probabilities
  - People substitute an easier question
  - "How do I feel about getting cancer?"
- The answer to this question does not require any technical understanding
  - Eliminates dealing with randomness, probabilities, and uncertainty

Horrors of Cancer

- Everyone knows of the horrors of cancer
- Prospects of cancer become an overwhelming influence on decisions for radiation safety
- While people may not be certain about the risks of radiation
  - They are certain that they do not want to become victims of cancer



How People Make Decisions for Safety

- When faced with imperfect, incomplete, or uncertain information?
- And chance or risk is involved, people's thought processes are often flawed
- We often make poor decisions when confronted with randomness or uncertainty
- We need to feel in control and randomness is not controllable

Opposing Intuition is Difficult

- Our minds are built to identify a definite cause for each event
- Therefore, it is difficult to accept the influence of unrelated or random factors
- Success or failure is often not a matter of great skill or incompetence, but chance
- **Are most of us where we are today by chance ?**

Like a Candle's Flame

- Our lives are coaxed in new directions by a variety of random events and how we respond to them
- Processes to assess risk of a tiger do not work very well for risks from radiation
- The parts of our brain that assess chance also handle our emotions
- The amygdala that responds to fear is also activated for decisions involving uncertainty (more discussion at WAM – 2)

Process for Safety Decisions

- Built on a house of cards
- Starting with radiation measurements
  - Huge uncertainties – often overlooked
  - Recorded data are believed to be real
- The meaning of measurements is whatever is attributed by you
- Intuitive evaluation of data does not account for randomness

Randomness and Safety Decisions

- Begins with measurements and many sources of (unknown) uncertainty
  - Many things can go wrong
  - Recorded numbers are taken as gospel
- Interpretation of measurements
  - Subject to individual perceptions
  - Related to fears "radiation = cancer"
- Decisions for action – What is at risk ?
  - Precautionary principle

Factors Affecting Uncertainty

1. Wrong detector or wrong probe
2. Instrument not working properly
3. Instrument not used properly
4. Calibration conditions
5. Energy dependence
6. Background interference
7. Backscatter and self absorption
8. Reading the wrong scale and mR / hr for beta
9. Minimum detectable activity (MDA)
10. Operator factors: fatigue, speed of probe, thoroughness of scan,

More Factors Affecting Uncertainty

1. Radiation is random
2. Variation in standards
3. Sensitivity of instruments
4. Counting time
5. Amount of radiation
6. Background / variations
1. Geometry
2. Uniformity of samples
3. Sample location
4. Sample selection bias
5. Sample preparation
6. Volume and weight errors

Uncovering the Truth

- Our brains are not wired to do probability problems very well.
- We determine the "truth" intuitively
- Human Intuition
  - Not suited to situations involving uncertainty
  - When chance is involved, thought processes are often seriously flawed
  - More discussion at Wednesday CEL and WAM – 2 PEP Class

Summary of Effects of Randomness

- People avoid dealing with randomness
  - Instead, decide how they feel about cancer
- People look for cause and effect intuitively
- Decisions on radiation safety begin with measurements that are very prone to errors
  1. Numerous uncertainties
  2. Mostly ignored for recorded data
- Interpretations are related to perceptions

Questions ?

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